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Estimating the prevalence of COPD in Canada: Reported diagnosis versus measured airflow obstruction

by Jessica Evans, Yue Chen, Pat G. Camp, Dennis M. Bowie and Louise McRae

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.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

Estimating the prevalence of COPD in Canada: Reported diagnosis versus measured airflow obstruction

by Jessica Evans, Yue Chen, Pat G. Camp, Dennis M. Bowie and Louise McRae

Abstract

Background

Estimates of chronic obstructive pulmonary disease (COPD) prevalence based on self-reports of a diagnosis are thought to underestimate the prevalence of COPD in Canada.

Data and methods

Pre-bronchodilator spirometry measures were obtained from the 2007 to 2009 Canadian Health Measures Survey for 2,487 individuals aged 35 to 79. The prevalence of self-reported chronic bronchitis symptoms and self-reported diagnosis by a health care professional was compared with the prevalence of measured airflow obstruction according to seven definitions, including the Global Initiative for Obstructive Lung Disease (GOLD) criteria.

Results

The prevalence of measured airflow obstruction compatible with COPD was two to six times greater than estimates based on self-reports of a diagnosis. An estimated 16.6% (95% CI: 14.3%-18.9%) of people aged 35 to 79 had pre-bronchodilator airflow obstruction as defined by ≥ GOLD stage I, and 8.1% (95% CI: 6.0%-10.2%) had ≥ GOLD stage II.

Interpretation

This study suggests that the prevalence of COPD in Canada has been underestimated.

Keywords

Chronic bronchitis, lung volume measurements, smoking, spirometry

Authors

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Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality in Canada.[1-6] COPD is typically described in terms of two conditions—*chronic bronchitis* and *emphysema*[7]—although asthma and other causes of chronic airflow obstruction are often included.[8-10] National estimates of COPD prevalence are approximately 4%,[11] based on survey respondents' reports of having been diagnosed with the condition. However, these estimates were not derived from objective lung function measures, and so are suspected to under-represent the true prevalence of COPD.[3,12]

Recently, using measured post-bronchodilator lung function data, the Burden of Lung Disease (BOLD) study[3] estimated the prevalence of COPD among randomly sampled Vancouver residents aged 40 or older to be 19%; the prevalence of moderate-to-severe COPD was 8%. Similarly, according to the results of lung function measurements for primary care patients aged 40 or older in Ontario, the prevalence of COPD was 21% among those with a smoking history; only one third of them were aware that they had the condition.[12] Such discrepancies between estimates based on self-reports versus lung function measurements could signal the existence in Canada of what has been reported in other countries[3,13,14]—a substantial number of people with undiagnosed COPD.

The objective of the current study was to compare prevalence estimates of COPD based on self-reports with those based on lung function measurements from cycle 1 of Statistics Canada's Canadian Health Measures Survey (CHMS).[15,16] This is the first time that lung function measurements have been reported for a nationally representative population in Canada.

Methods

Data source

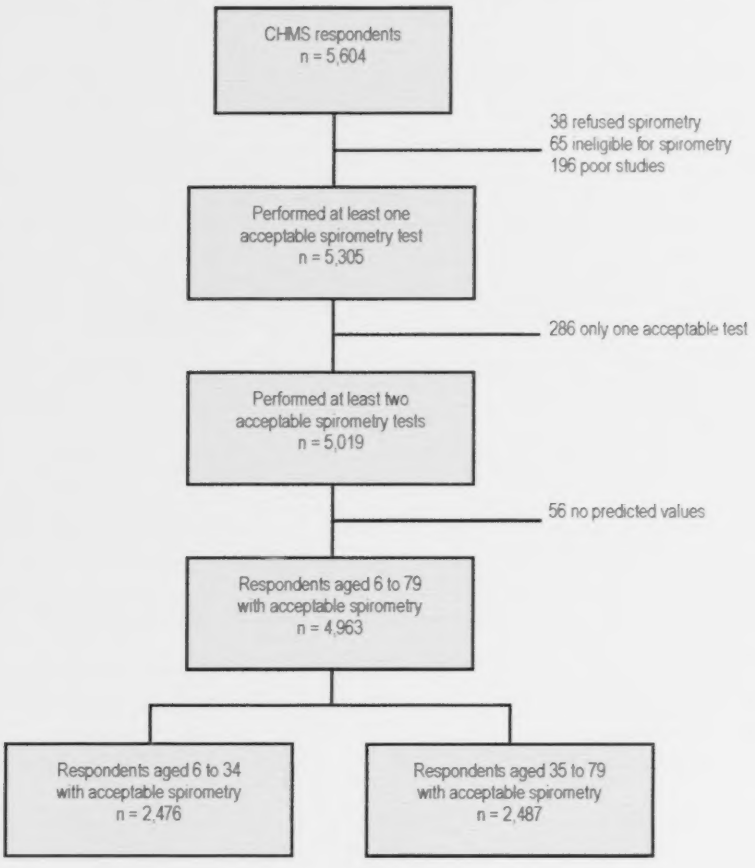
The Canadian Health Measures Survey (CHMS) covers the population aged 6 to 79 living in private households; residents of Indian Reserves or Crown lands, institutions and certain remote regions, and full-time members of the Canadian Forces are excluded. Data for cycle 1 were collected at 15 sites across the country from March 2007 through February 2009.

The CHMS involves an in-person interview to gather socio-demographic, health and lifestyle information, and a subsequent visit to a mobile examination centre for direct physical measures, including spirometry.

Of the households selected for the CHMS, 69.6% agreed to participate. Of these, 88.3% responded to the household questionnaire. Of those who completed that questionnaire, 84.9% reported to the mobile examination centre for direct physical measures, resulting in a total sample of 5,604 individuals.

The flow chart for recruitment of respondents and success with spirometry testing is shown in Figure 1. The current study pertains to the 2,487 respondents aged 35 to 79 who had good quality spirometry results.

Figure 1
Respondent recruitment and success with spirometry testing


CHMS respondents
n = 5,604
38 refused spirometry
65 ineligible for spirometry
196 poor studies
Performed at least one acceptable spirometry test
n = 5,305
286 only one acceptable test
Performed at least two acceptable spirometry tests
n = 5,019
56 no predicted values
Respondents aged 6 to 79 with acceptable spirometry
n = 4,963
Respondents aged 6 to 34 with acceptable spirometry
n = 2,476
Respondents aged 35 to 79 with acceptable spirometry
n = 2,487

Source: 2007 to 2009 Canadian Health Measures Survey.

Spirometry

Trained health measures specialists performed pre-bronchodilator spirometry testing according to American Thoracic Society (ATS) standards,[17,18] using a Koko Pneumotach spirometer (nSpire Health, Inc., Longmont, CO). The testing variables included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and their ratio (FEV_1/FVC). To be included in this analysis, a participant had to have at least two acceptable curves with both FVC and FEV_1 values repeatable within 250 millilitres. Predicted values for these lung function testing variables were derived from prediction equations for individuals aged 35 or older from the Third National Health and Nutrition Examination Survey (NHANES III) in the United States.[19] Percent predicted values and the lower limit of normal for each lung function testing variable were calculated.

In accordance with ATS standards,[17,18] respondents with only "one acceptable [spirometry] test" (Figure 1) were excluded from this study. A sensitivity analysis was conducted to assess the impact of excluding these individuals, given that some of them could have severe lung disease. When they were included in the analysis, the percentages meeting the various criteria for airflow obstruction did not differ notably from estimates that excluded them. Spirometry values were not available for individuals who refused, who were ineligible for spirometry, or who were labelled as having "poor studies" (Figure 1) because of invalid spirometry values; these individuals were not included in the sensitivity analysis.

Definitions of obstructive airway disease

Self-reported symptoms compatible with chronic bronchitis

Symptoms compatible with chronic bronchitis were defined as having a cough with phlegm for at least three months of the year during the past two consecutive years.[20]

Diagnosis of obstructive airway disease

All respondents were asked if a health care professional had ever diagnosed them as having "asthma," "chronic bronchitis," "emphysema" or "COPD." For the current study, individuals with diagnosed COPD were those who reported a health care professional diagnosis of "COPD," "chronic bronchitis" or "emphysema."

Airflow obstruction compatible with COPD

A modification (pre-bronchodilator data) of the Global Initiative for Obstructive Lung Disease (GOLD)[21] criteria and values for percent predicted and lower limit of normal from NHANES III[19] were used to assess seven spirometry-based categories of airflow obstruction compatible with varying degrees of COPD severity (Table 1). The effects of asthma could not be eliminated from this study because reversibility testing and clinical assessment of symptoms were not included.

Clinical variables assessed

Self-reported COPD symptoms

The presence of symptoms consistent with COPD was determined based on five questions related to: coughing regularly; coughing up phlegm regularly; simple chores causing shortness of breath; wheezing during exertion or at night; and getting frequent colds that persist longer that those of other people.[22]

Smoking history

Respondents who reported smoking fewer than 100 cigarettes in their lifetime were classified as "never smokers." Pack-years were defined as the number of cigarettes smoked per day divided by 20 and multiplied by the number of years that the respondent smoked. The pack-year ranges selected for analysis were: 10.0 to 19.9, 20.0 to 39.9, and 40 or more. The information needed to calculate pack years was not available for former occasional smokers; respondents in this group (n = 110) were assumed to have less than 10 pack-years.

Prescribed medication

Reported use of prescribed medication for obstructive airway disease, as defined by Anatomical Therapeutic Chemical (ATC) code R03, was assessed in this study.[23] The RO3 classification includes inhaled adrenergics, glucocorticoids and anticholinergics, and systemic drugs for obstructive airway disease. It was not possible to distinguish between asthmatics and individuals with COPD based on medication use, because treatment of the two conditions can overlap.

Statistical analysis

All analyses were performed with SAS Enterprise Guide version 4.1 (SAS Institute, Cary, NC). Point estimates were weighted to the Canadian population by applying sampling weights, which accounted for the unequal probability of being selected into the survey. Variances and 95% confidence intervals (CIs) were estimated using the bootstrap technique.[24,25] Positive and negative agreement indices and Kappa coefficients were assessed to compare the prevalence of self-reported diagnosed obstructive airway disease with measured airflow obstruction. Statistical significance was defined as $p < .05$.

Table 1
Spirometric definitions of airflow obstruction used in study

Pre-bronchodilator spirometry-based measures of airflow obstruction	GOLD stage
FEV_1 / FVC < 0.70	GOLD I or higher (fixed ratio)
FEV_1 / FVC < 0.70, FEV_1 < 80% predicted	GOLD II or higher
FEV_1 / FVC < 0.70, FEV_1 ≥ 80% predicted	GOLD I
FEV_1 / FVC < 0.70, 50% ≤ 50% FEV_1 < 80% predicted	GOLD II
FEV_1 / FVC < 0.70, FEV_1 < 50% predicted	GOLD III and IV
FEV_1 / FVC < LLN	Non-GOLD staging criteria
FEV_1 / FVC < LLN, FEV_1 < LLN	Non-GOLD staging criteria

FEV_1 = forced expiratory volume in one second
FVC = forced vital capacity
LLN = lower limit of normal
% = percent predicted (NHANES III)[19]
GOLD = Global Initiative for Chronic Obstructive Lung Disease[21]

Results

Airflow obstruction compatible with COPD

An estimated 2.6 million Canadians (17%) aged 35 to 79 had airflow obstruction compatible with at least GOLD I COPD severity, including 1.3 million individuals (8%) who had airflow obstruction compatible with at least GOLD II COPD severity (Table 2). Use of an FEV_1/FVC ratio below the lower limit of normal to define airflow obstruction, rather than a fixed ratio cut-off of 0.70 (GOLD I), yielded a lower prevalence estimate (12%) and was associated with a smaller increase in prevalence with advancing age. According to all definitions, except an FEV_1/FVC ratio below the lower limit of normal, measured airflow obstruction compatible with COPD was more prevalent among men than among women. The prevalence of moderate-to-severe COPD (GOLD III and IV in Table 1) was about 1% (95% CI: 0.4-1.4) (data not shown). This value was associated with high sampling variability and could not be further disaggregated by variables such as age and sex.

Self-reported symptoms of chronic bronchitis or diagnosed COPD

The prevalence of measured airflow obstruction was two to six times greater than the prevalence of self-reported symptoms compatible with chronic bronchitis and diagnosed COPD (Figure 2).

Depending on the definition, 5% to 15% of people aged 35 to 79 had airflow obstruction compatible with COPD, but did not report that they had been diagnosed with COPD by a health professional (Figure 3). Among them, 44% to 67% reported one or more symptoms compatible with COPD, and 45% to 55% had a smoking history of at least

20 pack-years (data not shown). By contrast, the prevalence of potential over-diagnosis was small, as only 2% of respondents reported having been diagnosed with COPD, but had no measured airflow obstruction (Figure 3). Overall agreement between self-reported diagnosed COPD and measures of airflow obstruction was minimal; kappa coefficients ranged from 0.1 to 0.2 for the four definitions of obstructive lung disease.

Airflow obstruction and smoking status

Among never-smokers, the measured prevalence of airflow obstruction compatible with COPD ranged from 2% to 9% (Table 2). The prevalence was higher among former smokers (5% to 16%), and higher still among current smokers (14% to 34%). The prevalence increased with pack-years smoked, reaching a range of 17% to 53% among those with 40 or more pack-years (Table 2).

Use of medication

An estimated 5% of people aged 35 to 79 had taken prescription medications for obstructive lung disease in the month before their CHMS spirometry testing. The prevalence of measured airflow obstruction among this group was three to six times higher than among people not taking such medications (Table 2).

Table 2
Prevalence of airflow obstruction compatible with chronic obstructive pulmonary disease,† by definition of airflow obstruction and selected characteristics, household population aged 35 to 79, Canada, 2007 to 2009

	Definition of airflow obstruction											
	GOLD I or higher severity (FEV_1 / FVC < 0.70)			Non-GOLD staging criteria (FEV_1 / FVC < LLN)			GOLD II or higher severity (FEV_1 / FVC < 0.70 + FEV_1 < 80%)			Non-GOLD staging criteria (FEV_1 / FVC < LLN + FEV_1 < LLN)		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
	%	from	to	%	from	to	%	from	to	%	from	to
Age group												
Total 35 to 79	16.6	14.3	18.9	11.9	9.9	13.9	8.1	6.0	10.2	5.7	4.1	7.2
35 to 49	10.0	6.4	13.5	10.6	7.1	14.1	4.8[E]	2.6	7.1	4.7[E]	2.5	6.9
50 to 59	17.6	13.5	21.6	13.2	9.7	16.7	8.5[E]	5.0	12.0	5.1	3.3	6.9
60 to 69	22.1	19.9	24.7	12.7	9.4	16.0	11.8[E]	7.4	16.2	7.3[E]	3.5	11.2
70 to 79	37.0	30.2	43.9	13.8	10.8	16.7	16.6	11.5	21.6	9.0[E]	5.7	12.4
Sex												
Men	18.4	14.5	22.7	11.9	8.1	15.8	9.0	6.1	11.9	6.6	4.1	9.2
Women	14.8	11.5	18.2	11.9	9.2	14.6	7.2	4.6	9.8	4.8	3.5	6.0
Body mass index (kg/m²)												
Normal (less than 25)	21.5	18.4	24.6	17.3	13.6	20.9	9.3	5.9	12.6	6.9[E]	4.3	9.6
Overweight (25 to less than 30)	14.9	11.1	18.7	8.9	6.1	11.8	7.3[E]	4.2	10.4	4.3[E]	2.3	6.4
Obese (30 or more)	11.9	9.1	14.7	8.6[E]	4.9	12.3	7.8[E]	4.4	11.1	6.0[E]	2.8	9.3
Smoking status												
Current smoker	33.5	25.0	41.9	29.7	22.1	37.2	20.0	12.9	27.0	14.1[E]	7.6	20.7
Former smoker	16.4	12.7	20.2	10.3	7.5	13.0	7.9[E]	4.9	11.0	5.4[E]	2.9	7.9
Never smoker	8.8	6.9	10.7	5.0	3.5	6.6	2.8	1.9	3.6	2.0[E]	1.1	2.9
10 to 19.9 pack-years	30.5	24.7	36.4	23.9	19.5	28.3	18.0	12.9	23.2	12.4	8.0	16.9
20 to 39.9 pack-years	39.1	32.2	45.9	30.9	26.6	35.3	23.9	18.2	29.7	16.4	11.5	21.2
40 or more pack-years	52.6	40.9	64.3	30.3	20.1	40.4	23.7	17.6	29.9	17.0	11.5	22.4
Self-reported symptoms and disease												
Symptoms of chronic bronchitis	39.1[E]	21.5	56.7	33.4[E]	16.3	50.6	25.8[E]	13.1	38.6	19.9[E]	9.8	30.1
Diagnosed chronic bronchitis	30.2[E]	15.1	45.3	24.1[E]	13.9	34.4	22.3[E]	10.8	33.9	17.8[E]	8.0	27.7
Diagnosed chronic obstructive pulmonary disease	39.6	29.3	49.9	35.7	27.0	44.3	31.7	24.0	39.4	22.6	15.5	29.7
Diagnosed asthma	40.5	31.1	49.9	33.4	25.6	41.2	28.4	19.3	37.4	24.2	15.2	33.2
Took medication for obstructive lung disease in past month												
Yes	41.1	31.9	50.3	36.1	27.6	44.6	33.9	24.1	43.7	29.2[E]	19.3	39.2
No	15.3	13.4	17.1	10.6	9.1	12.2	6.7	5.2	8.2	4.4	3.4	5.4
Sensitivity analysis‡												
35 to 79 years	16.6	14.7	18.6	11.8	10.1	13.6	8.1	6.3	9.9	5.6	4.3	6.9

GOLD = Global Initiative for Chronic Obstructive Lung Disease
FEV_1 = forced expiratory volume in one second
FVC = forced vital capacity
LLN = lower limit of normal
† pre-bronchodilator values
‡ includes respondents with poor quality spirometry (one acceptable spirometry)
[E] use with caution
Source: 2007 to 2009 Canadian Health Measure Survey

The percentage who reported taking medications for obstructive lung disease was highest among those who said they had been diagnosed with chronic bronchitis, COPD or asthma by a health professional (data not shown). Almost half of those who reported diagnosed COPD, but who did not have measured airflow obstruction, had taken medications for obstructive lung disease in the month before their CHMS spirometry testing.

Discussion

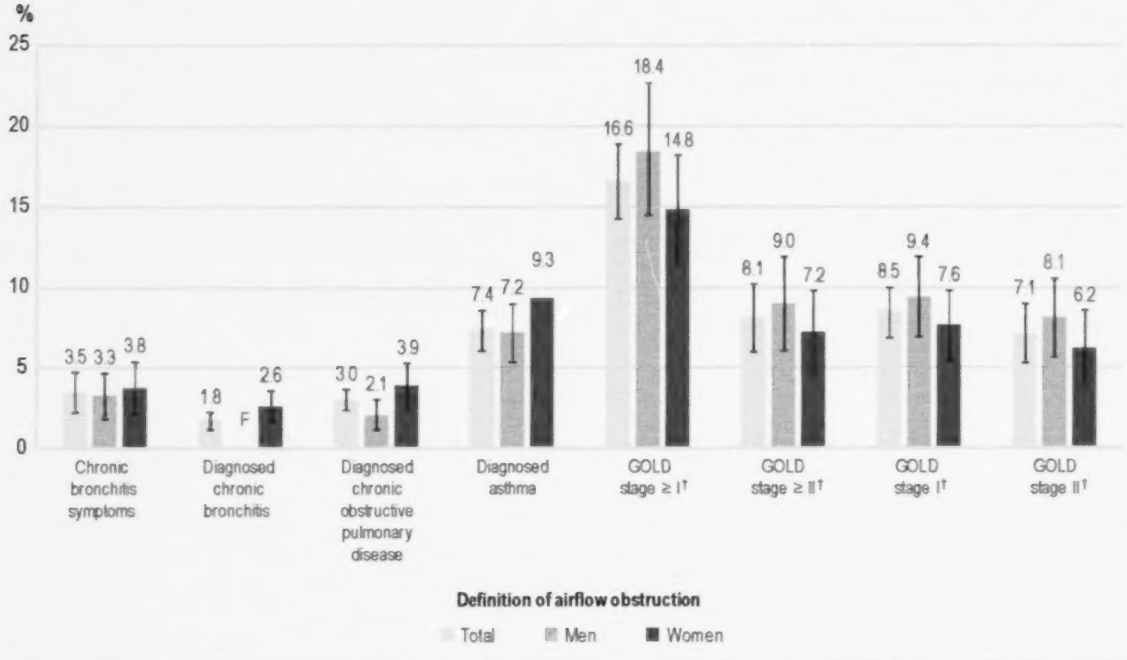
The prevalence of measured airflow obstruction was two to six times higher than estimates based on self-reports of having been diagnosed with COPD by a health professional. There was only slight agreement between self-reported diagnosed COPD and measured airflow obstruction compatible with COPD. Depending on the definition, 5% to 15% of the sample had measured airflow obstruction, but did not report a COPD diagnosis, even though about half were symptomatic and had a history of heavy smoking. This supports earlier studies suggesting that in Canada, as in other countries,[3,13,14,21] COPD symptoms are under-recognized and COPD is under-diagnosed.[5,11,12,26]

Fewer than 4% of the CHMS sample reported symptoms compatible with chronic bronchitis, which was considerably below the prevalence of measured airflow obstruction. This may reflect poor recall of symptoms or moderation of symptoms by the use of medications. As well, airflow obstruction can often be detected before the disease becomes symptomatic. In the current study, about half of those who did not report a diagnosis of COPD had measured airflow obstruction, reported symptoms consistent with COPD, and had a history of smoking.

Other investigators have observed that symptoms compatible with chronic bronchitis can be predictive of an accelerated loss of lung function with advancing age, of the risk of hospitalization,[27] and even of reduced longevity.[28] In primary care settings in Denmark, when people older than 35 with at least one respiratory symptom and risk factors such as smoking and occupational exposure were screened, 22% were newly diagnosed with COPD based on post-bronchodilator spirometry ($FEV_1/FVC < .70$).[29]

The potential over- and under-diagnosis of COPD in the present analysis may partially reflect infrequent use of spirometry in primary and non-respiratory specialist care. The 2008 Canadian

Figure 2
Prevalence of airflow obstruction, by sex and definition of airflow obstruction, household population aged 35 to 79, Canada, 2007 to 2009



I=95% confidence interval
GOLD = Global Initiative for Chronic Obstructive Lung Disease
† pre-bronchodilator values
F too unreliable to be published
Source: 2007 to 2009 Canadian Health Measures Survey

Community Health Survey found that fewer than two-thirds of people aged 35 or older who reported a diagnosis of COPD, emphysema or chronic bronchitis had had spirometry testing.[11] Similarly, an analysis of administrative data in British Columbia indicated that just over half of patients diagnosed with COPD had ever had a lung function test.[30]

From 60% to 77% of Canadians aged 35 to 79 who reported having been diagnosed with COPD did not meet the spirometry criteria for the condition (Table 2). Some of these cases may represent over- or misdiagnosis, but it is also possible that a few of these individuals had mild COPD and did not meet spirometry criteria as a result of taking medication before the CHMS test (almost half of them had used medication for obstructive lung disease in the previous month, including the day of the test). Without being able to distinguish between these possibilities, the extent of over-diagnosis cannot be determined.

The effect of multiple definitions of airflow obstruction was explored (Table 1). Although some experts favour a fixed ratio of $FEV_1/FVC < 0.70$ as a marker of significant airflow obstruction in the diagnosis of COPD,[21] there is growing opinion that the lower limit of normal for FEV_1/FVC, and even for FEV_1, is preferable.[31-35] The fixed ratio $FEV_1/FVC < 0.70$ tends to decline with advancing age, and so may fall below the 0.70 cut-off in healthy seniors,[31,36,37] which could lead to over-diagnosis of COPD in this group. By contrast, the lower limit of normal for FEV_1/FVC and FEV_1 seems to vary the least with factors such as age and sex[34,36] (male predominance for COPD prevalence based on the fixed ratio of $FEV_1/FVC < 0.70$ disappeared when analyzed in terms of the lower limit of normal for FEV_1/FVC). In the

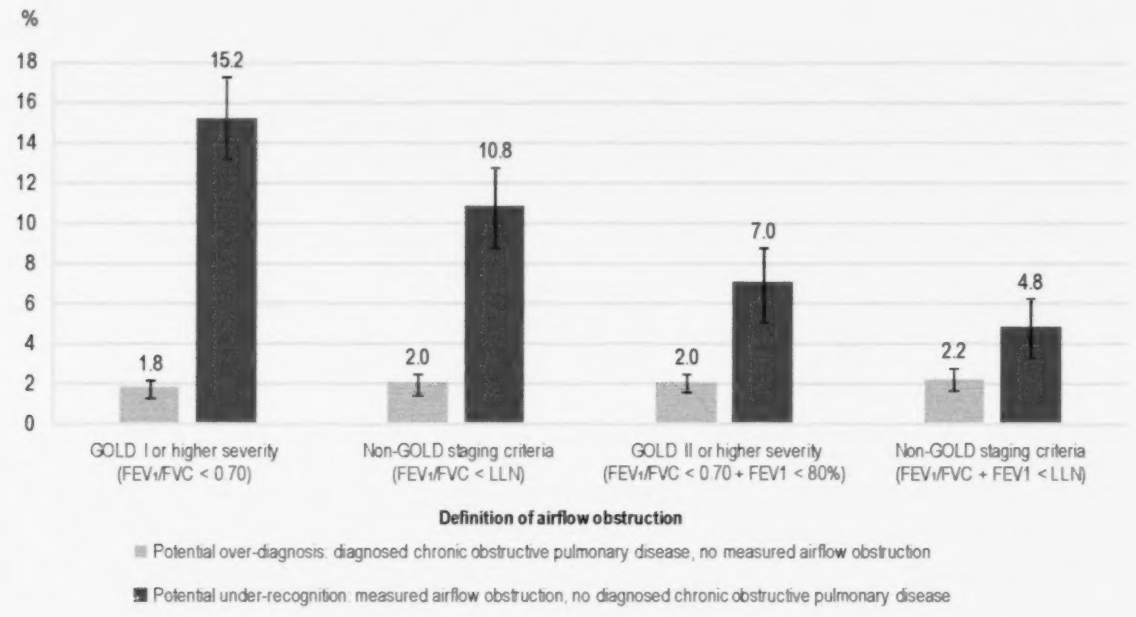
What is already known on this subject?

- Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality in Canada.
- Self-reports of a diagnosis may underestimate the prevalence of COPD.

What does this study add?

- The measured prevalence of airflow obstruction was two to six times higher than estimates based on self-reports of having been diagnosed with COPD by a health professional.
- Agreement between self-reported diagnosed COPD and measures of airflow obstruction was minimal.

Figure 3
Prevalence of potential over-diagnosis and under-recognition of COPD, by definition of airflow obstruction,† household population aged 35 to 79, Canada, 2007 to 2009



I=95% confidence interval
GOLD = Global Initiative for Chronic Obstructive Lung Disease
† pre-bronchodilator values
Source: 2007 to 2009 Canadian Health Measures Survey

current sample of people aged 35 to 79, use of the lower limit of normal for FEV_1/FVC yielded an estimated prevalence of airflow obstruction compatible with COPD of 12%; if the lower limit of normal for FEV_1 was included (indicating moderate-to-severe obstruction), the prevalence was 6%, comparable to the 7% observed in a slightly younger but larger sample in NHANES III.[14]

Limitations

The results of this study should be considered in the context of several limitations. These limitations include failure to quantify the potential role of occupational and other exposures, the age cut-off of 79, a low percentage of non-Caucasians in the sample, exclusion of some population groups at higher risk for COPD (for example, residents of Indian reserves), and the assumption that symptoms of chronic cough and phlegm were specific for COPD.

Another potential limitation was the use of pre- rather than post-bronchodilator spirometry data. For logistical reasons, most population-based studies of COPD, including the NHANES III,[14,38] have relied on pre-bronchodilator spirometry. However, the GOLD[21] guidelines for COPD diagnosis recommend post-bronchodilator spirometry, which implies that the best possible lung function of an individual should be used to classify disease.[39] Use of post- rather than pre-bronchodilator data can lower the estimated prevalence of COPD by 30% to 50%.[31,37,40] Thus, the prevalence estimates in this study must be interpreted with caution, as they may overestimate the true percentage by as much as half.

The rationale for using post-bronchodilator spirometry is to exclude asthma. However, such an exclusion cannot rely solely on reversibility testing[40] (positive response to bronchodilator), because an asthma diagnosis requires documentation of symptoms and airflow obstruction that are variable over time. While the return of lung function to normal or near-normal after bronchodilator administration strongly suggests a diagnosis of asthma, many COPD patients have a marked response to bronchodilators.[41,42] Furthermore, the presence or absence of bronchodilator reversibility is unlikely to affect the diagnosis of symptomatic, moderate-to-severe COPD in which airflow obstruction will never normalize.

An estimated 10% to 30% of patients with clinical COPD may also have a concomitant diagnosis of asthma. In part, this reflects true disease overlap, but it also illustrates that working definitions for these two diseases are imprecise and cannot rely on spirometry alone. The prevalence of airflow obstruction among never-smokers was higher than expected and could reflect asthma or other causes of airway disease, such as environmental or occupational exposure.[43] Some who reported having been diagnosed with asthma had COPD due to true disease overlap and COPD that was misdiagnosed as asthma. The majority of these individuals with reported asthma would likely have been identified as having some degree of lung obstruction compatible with COPD in this study, although people with milder cases, who were taking medication for lung obstruction, might have been missed. If their asthma was poorly controlled at the time of the test, some with asthma who did not have COPD may have been categorized as having COPD.[44-46]

The study was also limited in that individuals with moderate-to-severe COPD (GOLD stages III and IV) could not be assessed independently, although such cases are are the most important in terms of health care needs. The current study estimated the prevalence of moderate-to-severe COPD at 1%, an estimate that was associated with large variation. Combining subsequent cycles of the CHMS should make it possible to obtain the statistical power required to quantify and describe this group.

Conclusions

This study, based on physical measures from the Canadian Health Measures Survey, supports earlier evidence suggesting that the extent of COPD in Canada may be underestimated. Clinicians, health care researchers, patients and those responsible for health care planning and provision will benefit from more accurate information about the lung health of Canadians. ■

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